

Automated search for star clusters in large multiband surveys: II. Discovery and investigation of open clusters in the Galactic plane

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Abstract — Automated search for star clusters in J, H, K_s data from 2MASS catalog has been performed using the method developed by Koposov et. al (2008). We have found and verified 153 new clusters in the interval of the galactic latitude $-24^\circ < b < 24^\circ$. Color excesses $E(B - V)$, distance moduli and ages were determined for 130 new and 14 yet-unstudied known clusters. In this paper, we publish a catalog of coordinates, diameters, and main parameters of all the clusters under study. A special web-site available at <http://ocl.sai.msu.ru> has been developed to facilitate dissemination and scientific usage of the results.

Key words: *open clusters, all-sky surveys*

INTRODUCTION

The search for star clusters in the Galaxy is of a great interest for investigators in the recent years. On the one hand, the usage of new methods and instruments in observations allows scientists to involve clusters in solving a larger number of astrophysical problems and raises many new ones, such as: the processes of formation and evolution of young massive clusters, the nature of nuclear star clusters, the presence of multiple populations in globular clusters. On the other hand, the availability of new multiband all-sky surveys stimulates us to search them for new clusters and build a homogeneous catalog of parameters of both newly discovered and already known clusters.

In Paper I (Koposov et al. 2008), we described the new method of an automated search for star clusters as a density peaks in huge stellar catalogs. It is based on the convolution of density maps with a special 2-D filter, which is the difference between two 2-D Gaussian profiles and has zero integral. If convolved with this special filter, the areas of flat or slowly changing background would produce zero signal, whereas the areas of star concentrations would exhibit a high signal. Using this method, we analyzed the distribution of stars in Two Micron All Sky Survey (2MASS) in the field of 16×16 degrees towards the Galactic anticenter and found 15 new open clusters. To verify the reality of detected clusters, we developed a method, which is based

on the assumption that probable cluster members lying along the same isochrone on the color-magnitude diagram (CMD) should also form the spatial density peak, whereas the background stars should have a flat distribution. The other benefit of this method is that it not only allows to verify a cluster candidate, but at the same time estimates the cluster's main parameters – distance, age, and color excess. We employed this method to derive parameters of 12 new and 13 known, but poorly studied clusters, which were also detected in the field of interest, using the technique of $(J, J - H)$ and $(K_s, J - K_s)$ diagrams built with the data from 2MASS catalog. Later, $UBVI$ magnitudes of the stars in three new clusters were measured using CCD images taken at 104-cm telescope of Aryabhatta Research Institute of Observational Sciences (ARIES, India). The isochrones fitted to these data using another color-magnitude diagrams, and derived clusters parameters (Glushkova et al. 2009) show good agreement with those obtained from $(J, J - H)$ and $(K_s, J - K_s)$ 2MASS diagrams and therefore independently confirm the reality of clusters found by Koposov et al. (2008) and the correctness of the method of new cluster verification.

The aims of this study are: (1) search for overdensities in the Galactic plane in the range of the galactic latitude $|b| < 24^\circ$ using 2MASS data; (2) verification of some of them as a real clusters; (3) estimate of their physical parameters using proven technique we have developed earlier.

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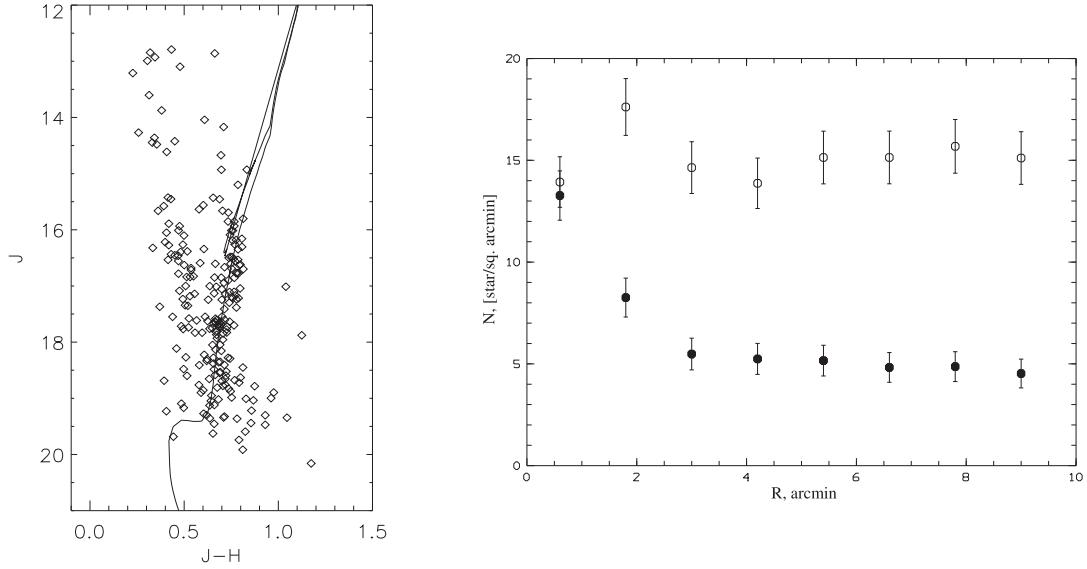


Fig. 1. Left panel: $(J, J - H)$ diagram of the stars within $3'$ from the center of the SAI 50 built by data from UKIDSS GPS with the fitted isochrone. Right panel: Radial density distribution. Solid circles represent the density of cluster members lying along the fitted isochrone not far than $0^m.05$ in $(J - H)$ direction. Open circles denote the density of the field stars.

SEARCH FOR NEW CLUSTERS AND DETERMINATION OF THEIR PARAMETERS

For the new clusters search and verification procedures we made use of <http://vo.astronet.ru>, the Virtual Observatory (VO) resource of the Sternberg Astronomical Institute (Koposov et al. 2007), which provides fast remote access to 2MASS catalog data through the standard VO-compliant interfaces. We detected 11186 overdensities with the significance level of more than $4.5 \times \sigma$ in the region of the Milky Way within the interval of the galactic latitude $-24^\circ < b < 24^\circ$. Since the open clusters subsystem concentrates to the Galactic plane where the interstellar extinction reaches maximum and the background changes rapidly, the most from 11186 overdensities should be attributed to the fluctuations of interstellar dust especially towards the Galactic center, where the density fluctuations are maximal. We undertook a visual inspection of all detected overdensities by images from Digitized Sky Survey (DSS) and 2MASS catalogs to recognize real density concentrations against these background fluctuations. We selected 962 candidates to clusters and matched them to the online catalogs by Dias et al. (2002) and Harris (2003). This match demonstrated that 565 candidates are known open clusters, 114 are known globular clusters, whereas 283 overdensities should be examined in detail as a new cluster candidates, some of which may only be attributed to random

star concentrations. We ran all these 283 overdensities through our verification procedure, which includes the analysis of their Hess-diagrams, color-magnitude diagrams and radial density distributions in accordance with the technique by Koposov et al. (2008). 149 candidates were decided to be the real star clusters.

However, a part of non-selected overdensities may also be real clusters, which we were unable to verify, because they were detected at the sensitivity limit of 2MASS catalog. If we extend our data pattern with the data from the sources with a higher limit in J, H, K magnitudes, then some other overdensities may manifest themselves as real clusters, and their parameters can also be determined. We tested this idea by using Galactic Plane Survey of UKIRT Infrared Deep Sky Survey, Data Release 3 (UKIDSS GPS DR3, Warren et al. 2007) as an additional data source. The average 2MASS sensitivity in K_s is $14^m.3$, whereas in UKIDSS GPS, the magnitude limit for K -band is as high as $19^m.22$ cluster candidates found in 2MASS were studied by $(J, J - H)$ and $(K, J - K)$ diagrams and radial density distributions built using data from UKIDSS GPS. We verified 9 star clusters and determined their distance moduli, ages and color excesses. Among these nine objects, four (SAI 50, SAI 131, SAI 133, and SAI 141 in Table 1) did not reveal themselves as star clusters when only 2MASS catalog data were employed, because the upper part of their main sequences and/or red giant

branches is only seen on CMD and Hess-diagrams. For example, left panel of Fig. 1 displays $(J, J - H)$ diagram of cluster SAI 50 built by data from UKIDSS GPS. One can only see here the red-giant branch limited to the stars fainter than $J = 16^m$. If we build such a CMD for this cluster with 2MASS data only, we would not detect the cluster at all, because the limiting magnitude for J -band in this catalog is exactly 16^m . In Fig. 1, the isochrone is fitted to give the lower estimate of the distance to the cluster.

Thus, after involving UKIDSS GPS data, the number of confirmed clusters reached 153. For 130 clusters we automatically obtained main physical parameters: ages, distances and color excesses using the data from 2MASS or UKIDSS GPS and isochrones of solar metallicity by Girardi et al. (2002). J, H, K magnitudes were taken from the deeper UKIDSS GPS for the nine clusters, whose centers fall into this survey: SAI 50, SAI 74, SAI 75, SAI 130, SAI 131, SAI 133, SAI 141, SAI 142, SAI 145. The center coordinates, diameters, color excesses $E(B - V)$, distance moduli and ages as $\log(t)$ are listed in Table 1. We consider the position of the maximum in a density peak as the center of a cluster on the density map. The cluster radius is such a distance from its center, at which the star density becomes flat on the radial density distribution plot. The errors in color excesses, distance moduli and ages were estimated as described by Koposov et al. (2008): from the differences in the parameters derived by $(J, J - H)$ and $(K_s, J - K_s)$ diagrams. We used the relations $A_{K_s} = 0.670 \times E(J - K_s)$, $A_J = 0.276 \times A_V$, $E(J - H) = 0.33 \times E(B - V)$ from the paper by Dutra et al. (2002) to derive the distance modulus and color excess $E(B - V)$, and the relation $A_K = 0.626 \times E(J - K)$ from the paper by He et al. (1995) for K magnitudes from UKIDSS GPS. For some clusters, we are able to estimate the upper limit of the age only, in particular, when their color-magnitude diagrams do not contain red-giant stars. Besides the cluster name SAI (*Sternberg Astronomical Institute*), other names from papers by Kronberger et al. (2006) and by Froebrich et al. (2007) are used in Table 1. As mentioned by Koposov et al. (2008), the authors of both papers published the list of probable cluster candidates where further investigation is necessary to clarify their nature. Some of the overdensities independently found by us coincide with the cluster candidates from papers by Kronberger et al. (2006) and Froebrich et al. (2007). We performed a thorough analysis of these matching candidates and confirmed some of them as the real clusters. However, remaining candidates turned to be mere random star concentrations or background fluctuations (we do not publish this list here). All clusters from Table 1 having the other name according to Kronberger et al. (2006) or Froebrich et al. (2007), are listed neither

in the database of open clusters (WEBDA) by Paunzen, Mermilliod (2009), nor in the catalog by Dias et al. (2002). That is why we consider them as a new clusters.

Special attention should be given to the cluster SAI 92 from Table 1. This cluster is situated $7'$ to the south-east of NGC 2645, and both clusters feature approximately the same values of parameters. According to WEBDA, the distance from Sun to NGC 2645 equals to 1668 pc; we estimate the distance to the cluster SAI 92 to be 1580 ± 130 pc. Color excess $E(B - V)$ in the direction to NGC 2645 is $0^m.380$, and to SAI 92, $0^m.39 \pm 0^m.10$. Both clusters are pretty young, but differ in $\log(t)$ by 0.72: WEBDA estimates the age of NGC 2645 as 7.283, whereas the present study gives 8.00 ± 0.05 for SAI 92. However, 0.05 is the formal error, which, as mentioned earlier, should be attributed to the difference in the ages determined by $(J, J - H)$ and $(K_s, J - K_s)$ diagrams. A real error for age estimate by 2MASS is not less than 0.3 for clusters which do not contain stars on the red-giant branch. If we build the $(V, B - V)$ diagram of NGC 2645 using data from WEBDA and fit them by the isochrone of solar metallicity by Girardi et al. (2002) using the distance and color excess also from WEBDA, then the lower limit for the age is 7.6 in $\log(t)$. Therefore, the age of both clusters can be considered approximately the same taking into account the real errors of its estimate. Apparently, NGC 2645 and SAI 92 form a double cluster then. Fig. 2 shows the image of $15' \times 15'$ from DSS where both clusters fall into. Diameters of clusters ($5'$ and $3'$) are represented by circles.

SAI 50 looks like a globular cluster by its age and CMD built using data from UKIDSS GPS, although the errors in parameters are large, because the isochrone was fitted to the red-giant branch only. The left panel of Fig. 1 represents $(J, J - H)$ diagram with fitted isochrone; the radial density distribution corresponding to this fitted isochrone is displayed in the right panel. Solid circles denote the cluster members that are the stars deviating from the isochrone by less than $0^m.05$ in color; open circles denote background stars, that are all other stars. It can clearly be seen that the members of the cluster are concentrated to its center, whereas field stars exhibit flat distribution with small density fluctuations.

Besides 130 clusters which are listed in Table 1, we found 23 new embedded clusters. They are detected as density peaks and are clearly visible on 2MASS images and Hess-diagrams. But such a clusters reveal themselves as a cloud on the CMD $(J, J - H)$ and $(K_s, J - K_s)$; therefore, it was impossible to fit isochrones and find their parameters. Coordinates and diameters of these clusters are presented in Table 2.

Table 2. Coordinates of new embedded clusters

Cluster	Other name	α_{J2000} <i>h m s</i>	δ_{J2000} $^{\circ} / ' / ''$	d '
SAI 10		00:43:03.2	+41:37:21	3
SAI 15		01:49:52.6	+53:54:34	2
SAI 18		02:21:55.9	+61:07:21	3
SAI 19		02:26:31.9	+61:59:33	6
SAI 20	FSR 584	02:27:04.8	+61:37:40	6
SAI 22		02:48:58.1	+60:44:34	5
SAI 23		02:54:05.0	+60:39:52	2
SAI 24		02:59:25.4	+60:33:58	6
SAI 28		03:39:16.7	+55:58:24	3
SAI 32	FSR 655	03:56:11.8	+53:52:09	1
SAI 38	FSR 699	04:56:05.6	+47:23:25	2
SAI 39	FSR 696	04:58:31.6	+47:59:03	1
SAI 52	FSR 812	05:38:09.1	+31:44:16	3
SAI 53	FSR 874	05:40:58.3	+20:21:18	3
SAI 54	FSR 855	05:42:22.4	+22:50:04	3
SAI 55	FSR 826	05:42:51.2	+28:56:43	3
SAI 97	FSR 1432	08:52:53.3	-44:12:06	4
SAI 113		10:22:43.6	-59:30:20	2
SAI 119	FSR 1662	13:44:14.2	-62:04:03	2
SAI 125	FSR 31	18:06:27.8	-21:23:27	5
SAI 126		18:13:26.7	-17:52:49	3
SAI 134	FSR 198	20:02:26.8	+35:40:34	4
SAI 152	FSR 469	23:57:04.4	+65:24:52	1

INVESTIGATION OF YET-UNSTUDIED KNOWN CLUSTERS

Table 3 lists the coordinates, diameters, color excesses $E(B-V)$, distance moduli, distances in pc, and $\log(t)$ of known, but yet-unstudied clusters. We detected and investigated all clusters by our methods, which simultaneously allowed us to improve the accuracy of the center coordinates. For instance, one of the overdensities was attributed to the open cluster Berkeley 53, although it is situated $10'$ away to the west from the coordinates contained in the catalog by Dias et al. (2002). WEBDA gives the same position and the DSS image shows no star concentration there. Hence, Be 53 was not studied previously.

WEBDA misses all *ESO* clusters, whereas the Dias' catalog lists their coordinates and diameters only. *ESO* 311-21 is marked by Dias et al. (2002) as “doubtful”, and *ESO* 211-03, as “not found”. Diameter of cluster *ESO* 368-11 is $1'$ according to Dias et al. (2002), but we found it to be $6'$. Diameters of other known clusters are also less then that in Dias' catalog as compared to the data from Table 3 in this paper. This difference can be explained by the fact that all these clusters are barely perceptible on DSS images, but well noticeable on images from 2MASS. Diameters presented in Table 3 were derived from radial density distribution plots in the same manner as for newly discovered clusters.

Dias' catalog and WEBDA only give the coordinates and underestimated diameters for all *Ruprecht* clusters from Table 3. Open cluster *BH* 131 is marked as

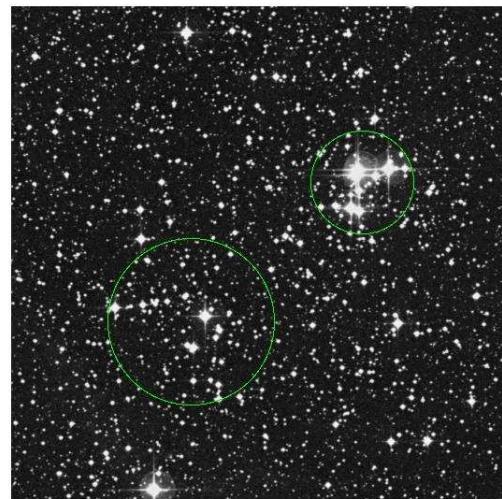


Fig. 2. DSS image of double star cluster SAI 92 and NGC 2645 in the field of $15' \times 15'$. Circles represent the cluster diameters, $5'$ and $3'$ correspondingly.

“doubtful” by Dias et al. (2002), *Trumpler* 19 has no data in the literature available. Koposov et al. (2008) published the coordinates and diameters only for cluster *Koposov* 7, whereas in present work we determined its age, distance and color excess using the data from UKIDSS GPS.

SAI OPEN CLUSTERS CATALOG

To facilitate dissemination and scientific usage of the results of the present study and data from Koposov et al. (2008), we have developed a standardized tool for continuous publication of the results of ongoing catalog compilation on the Web, available as a dedicated web-site at <http://ocl.sai.msu.ru>. Besides the standard access via a web browser to the catalog of individual cluster pages with Hess-diagrams, color-magnitude diagrams, 2MASS or DSS cluster images, and catalogs of photometric data (for clusters with CCD observations), the web-site offers the catalog exported to CSV, DAT, and VOTable formats as well and implements a standard Virtual Observatory programmatic access interface for positional queries called *ConeSearch*. Moreover, it is possible to start the VO client software, such as TOPCAT¹ or CDS ALADIN², by a single click in a web browser with the catalog preloaded for quick-look analysis of the whole sample and all accompanying data we provide for individual clusters.

Main results are available as a single table at Centre de Donnees astronomiques de Strasbourg at

¹<http://www.star.bris.ac.uk/~mbt/topcat/>

²<http://aladin.u-strasbg.fr/>

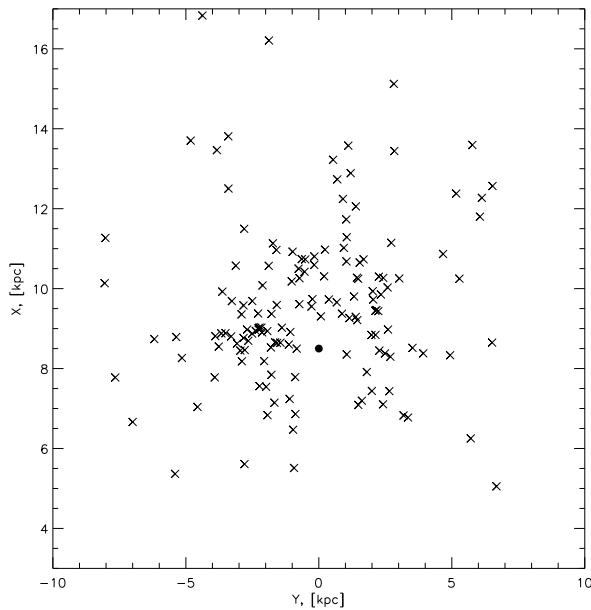


Fig. 3. Distribution of 143 open clusters across the Galactic plane. Solid circle denotes the Sun.

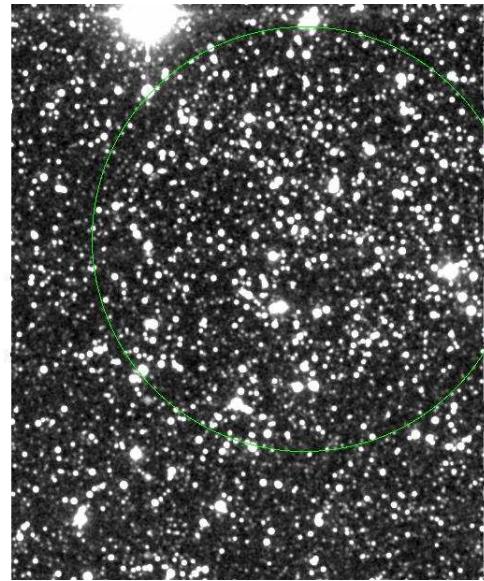


Fig. 5. 2MASS image of cluster SAI 132, diameter is $8'$.

<http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=V/132> and also within standalone VO client applications running on any workstation connected to the Internet, e.g. mentioned TOPCAT and CDS ALADIN tools, using query to search for the catalogs by key words or by authors of this publication.

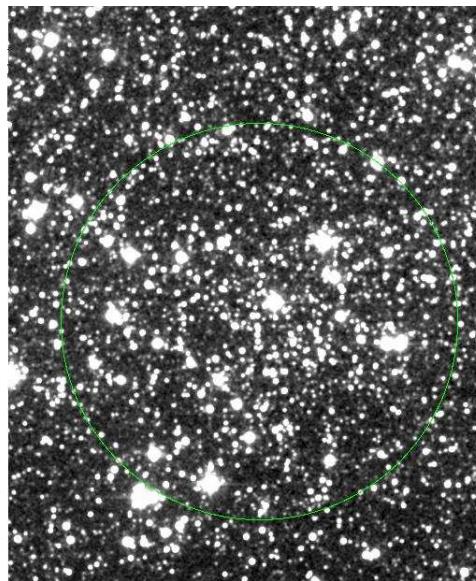


Fig. 4. 2MASS image of cluster SAI 122, diameter is $8'$.

CONCLUSIONS

Using J, H, K_s photometric data available in 2MASS catalog, we have performed an automated search for the star overdensities in the Galactic plane for the latitudes ranged within $|b| < 24^\circ$ and detected 11186 density peaks. A short list of 283 new cluster candidates has been compiled after we excluded the overdensities attributed to the background fluctuations or star concentrations coinciding with already known clusters. Employing our method described earlier (Koposov et al., 2008), we have studied these 283 candidates and verified 149 of them to be real clusters. Having involved the UKIDSS GPS survey in our investigation as an additional data source, we studied 22 more cluster candidates and found four new open clusters. Therefore, the number of new clusters found in the frame of the present paper is 153. For 130 clusters of them, we have determined their main physical parameters: distance, age, and color excess. Together with the clusters published in Koposov et al. (2008), we have found 168 new open clusters in total, and determined parameters for 142 of them. Besides that, we confirmed the existence of 14 known, but yet-unstudied clusters and determined their accurate coordinates and other parameters. Fig. 3 shows the distribution of 143 open clusters projected onto the Galactic plane. The crosses denote all clus-

ters, except for SAI 50, whose distances are determined in this paper (129 new and 14 known clusters). We excluded cluster SAI 50 from this pattern because of large errors in its parameters. Solid circle represents the Sun. It can be clearly seen from this figure that no new clusters were discovered in the direction towards the Galactic center, because this area features maximum extinction and level of background fluctuations, which makes the detection of clusters more difficult. The major part of new clusters have been found within the radius of 2.5 kpc from the Sun, because of a relatively low limiting values of J, H, K_s in the 2MASS catalog. We have not discovered any new clusters closer than 500 pc; however, we did not attempt to search for them specifically in this range of the distance, because the open cluster sample there is believed to be complete. For this reason, we used the filter allowing to detect clusters with the diameter of 10' and less, whereas for the close clusters this value is typically greater.

Some new rich clusters can only be seen at the IR wavelengths. For example, SAI 122 is well noticeable on the image from 2MASS data (Fig. 4) and is fully invisible on the DSS images, because the color excess in the direction toward this cluster amounts to $2^m.26$. Among the clusters discovered by us, there are few, which reveal themselves on the DSS images as a very faint objects; however, it is normally impossible to estimate their parameters. The majority of new objects are either poorly populated clusters, or rich ones, yet imperceptible against a dense background: for example, SAI 132 (see Fig. 5). In both these cases, an object cannot be detected while visually inspecting 2MASS images. Thus, the application of our automated method of searching infrared data for density peaks has provided us with the tool capable of detecting these 168 open clusters.

This work has made use of WEBDA database, operated at the Institute for Astronomy of the University of Vienna and developed by E. Paunzen and J.-C. Mermilliod.

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This work is based in part on data obtained as part of the UKIRT Infrared Deep Sky Survey.

This publication has made use of the Digitized Sky Surveys which were produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. The images of these surveys are based on photographic data obtained using the Oschin Schmidt

Telescope on Palomar Mountain and the UK Schmidt Telescope.

This research has made use of the SAI Catalog Access Services, Sternberg Astronomical Institute, Moscow, Russia.

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REFERENCES

1. E. V. Glushkova, R. S. Yadav, S. E. Koposov, in preparation (2009).
2. W. S. Dias, B. S. Alessi, A. Moitinho, J. R. D. Lepine, *Astron. Astrophys. J.* **389**, 871 (2002) and online version www.astro.iag.usp.br/~wilton/clusters.txt
3. C. M. Dutra, B. X. Santiago, E. Bica, *Astron. Astrophys.* **381**, 219 (2002).
4. L. Girardi, G. Bertelli, A. Bressan, et al., *Astron. Astrophys.* **391**, 195 (2002).
5. S. Koposov, O. Bartunov, A. Belinskiy, S. Karpov, *Astronomical Society of the Pacific Conference Series* **376**, 34 (2007).
6. S. E. Koposov, E. V. Glushkova, I. Yu. Zolotukhin, *Astron. Astrophys.* **486**, 771 (2008).
7. M. Kronberger, P. Teutsch, B. Alessi, et al., *Astron. Astrophys.* **447**, 921 (2006)
8. E. Paunzen, J.-C. Mermilliod, WEBDA online version <http://www.univie.ac.at/webda> (2009)
9. D. Froebrich, A. Scholz, C. L. Raftery, *MNRAS* **374**, 399 (2007)
10. L. He, D. C. B. Whittet, D. Kilkenny, J. H. Spencer Jones, *Astrophys. J. Suppl. Ser.* **101**, 335 (1995).
11. W. E. Harris, *Astron. J.* **112**, 1487 (1996) and online version www.physics.mcmaster.ca/Globular.html (2003).
12. *The Two Micron All Sky Survey* M.F. Skrutskie, R.M. Cutri, R. Stiening, et al., *Astron. J.* **131**, 1163 (2006).
13. *UKIDSS Galactic Plane Survey* S. J. Warren, N. J. G. Cross, S. Dye, et al., arXiv:astro-ph/0703037 (2007)

Table 1. Parameters of new clusters

Name	Other name	α_{J2000} <i>h m s</i>	δ_{J2000} $^{\circ} \text{ } ' \text{ } ''$	d /	E(B-V) mag	$(m - M)_0$ mag	Age $\log(t)$
SAI 1		00:08:20.4	+51:43:15	4	0.34 \pm 0.14	11.68 \pm 0.06	9.10 \pm 0.05
SAI 2		00:12:28.4	+76:14:06	5	0.81 \pm 0.27	12.45 \pm 0.26	<7.70
SAI 3	FSR 480	00:14:49.6	+61:28:36	6	0.68 \pm 0.02	14.18 \pm 0.05	9.20 \pm 0.05
SAI 4		00:23:40.0	+62:42:14	4	0.27 \pm 0.18	11.02 \pm 0.36	<8.70
SAI 5	FSR 494	00:25:37.8	+63:45:40	4	0.60 \pm 0.08	12.70 \pm 0.07	9.10 \pm 0.05
SAI 6		00:27:52.6	+60:41:21	5	0.89 \pm 0.09	12.17 \pm 0.01	<8.50
SAI 7	FSR 503	00:29:11.3	+68:56:11	7	0.82 \pm 0.12	11.88 \pm 0.38	9.40 \pm 0.05
SAI 8	FSR 505	00:40:08.8	+61:34:03	3	0.30 \pm 0.11	14.28 \pm 0.20	9.15 \pm 0.10
SAI 9	FSR 508	00:41:51.9	+64:58:51	4	0.66 \pm 0.17	14.42 \pm 0.20	9.10 \pm 0.10
SAI 11	FSR 524	00:57:12.4	+62:06:18	8	0.51 \pm 0.13	10.70 \pm 0.29	9.10 \pm 0.05
SAI 12		01:04:24.1	+45:36:25	4	1.13 \pm 0.30	12.06 \pm 0.02	<8.15
SAI 13	FSR 536	01:19:37.6	+63:03:20	8	1.27 \pm 0.23	12.38 \pm 0.17	<8.20
SAI 14		01:26:00.3	+62:37:33	4	0.55 \pm 0.03	14.05 \pm 0.03	9.10 \pm 0.05
SAI 16		02:05:29.6	+62:15:54	5	0.70 \pm 0.01	14.42 \pm 0.20	9.15 \pm 0.05
SAI 17		02:20:48.3	+59:11:06	2	0.98 \pm 0.17	12.88 \pm 0.10	8.90 \pm 0.05
SAI 21		02:34:45.4	+62:34:22	3	0.58 \pm 0.01	11.35 \pm 0.10	<8.50
SAI 25		03:00:26.7	+57:16:02	7	0.84 \pm 0.13	11.80 \pm 0.09	9.15 \pm 0.05
SAI 26		03:09:30.8	+56:47:26	3	1.47 \pm 0.29	11.79 \pm 0.51	<8.20
SAI 27		03:11:21.9	+68:54:01	5	0.62 \pm 0.04	10.48 \pm 0.28	9.25 \pm 0.10
SAI 29	FSR 634	03:40:21.5	+59:24:52	5	0.84 \pm 0.01	12.24 \pm 0.07	9.00 \pm 0.05
SAI 30		03:40:22.2	+82:13:60	3	1.25 \pm 0.44	12.46 \pm 0.05	<8.00
SAI 31		03:51:15.4	+58:46:08	6	0.16 \pm 0.22	12.12 \pm 0.02	9.60 \pm 0.05
SAI 33	Juchert 19	04:02:20.2	+52:26:39	2	0.28 \pm 0.01	10.64 \pm 0.02	<9.30
SAI 34	FSR 660	04:02:37.8	+51:55:50	5	1.20 \pm 0.12	13.78 \pm 0.03	9.10 \pm 0.05
SAI 35	Juchert 20	04:10:47.0	+46:52:01	5	0.70 \pm 0.18	11.92 \pm 0.02	<8.55
SAI 36		04:16:50.4	+41:04:00	3	0.55 \pm 0.05	12.36 \pm 0.19	9.10 \pm 0.05
SAI 37	FSR 687	04:39:27.1	+48:12:23	4	0.77 \pm 0.03	14.30 \pm 0.04	9.15 \pm 0.05
SAI 40		05:00:56.9	+41:14:02	8	0.35 \pm 0.12	13.29 \pm 0.05	8.75 \pm 0.05
SAI 41		05:07:05.4	+38:25:05	2	0.51 \pm 0.18	13.58 \pm 0.23	9.30 \pm 0.05
SAI 42	Juchert 23	05:07:39.7	+17:36:00	8	0.62 \pm 0.18	11.67 \pm 0.09	8.70 \pm 0.05
SAI 43		05:08:16.6	+49:52:08	2	0.18 \pm 0.03	12.92 \pm 0.07	8.95 \pm 0.05
SAI 44	FSR 716	05:11:07.4	+45:43:09	5	0.24 \pm 0.01	12.64 \pm 0.06	8.95 \pm 0.05
SAI 45	FSR 727	05:16:35.0	+45:34:56	6	0.25 \pm 0.02	10.55 \pm 0.17	9.20 \pm 0.05
SAI 46		05:19:37.0	+36:30:32	3	0.78 \pm 0.01	13.16 \pm 0.12	9.45 \pm 0.05
SAI 47		05:23:58.0	+42:18:52	3	0.60 \pm 0.01	12.93 \pm 0.05	8.50 \pm 0.05
SAI 48		05:24:16.8	+33:30:02	4	0.31 \pm 0.07	11.30 \pm 0.20	9.35 \pm 0.05
SAI 49		05:26:24.9	+50:47:03	6	0.47 \pm 0.01	12.17 \pm 0.17	9.05 \pm 0.05
SAI 50		05:28:38.9	+35:01:19	3	0.60 \pm 0.30	16.70 \pm 0.50	9.70 \pm 0.20
SAI 51		05:30:01.9	+33:25:31	3	0.62 \pm 0.18	9.54 \pm 0.20	<9.30
SAI 56	FSR 852	05:53:30.6	+25:10:41	8	0.43 \pm 0.07	11.82 \pm 0.04	8.90 \pm 0.05
SAI 57	FSR 932	06:04:21.5	+14:34:22	5	0.39 \pm 0.07	10.18 \pm 0.10	8.90 \pm 0.10
SAI 58	FSR 921	06:05:09.4	+16:41:03	5	1.33 \pm 0.33	11.80 \pm 0.20	8.50 \pm 0.05
SAI 59	FSR 942	06:05:59.2	+13:39:52	8	0.59 \pm 0.01	11.51 \pm 0.25	9.00 \pm 0.05
SAI 60		06:06:38.6	+15:56:51	4	0.90 \pm 0.01	14.50 \pm 0.05	9.05 \pm 0.05
SAI 61	FSR 904	06:06:55.2	+19:00:26	8	0.14 \pm 0.16	10.51 \pm 0.02	8.80 \pm 0.05
SAI 62	FSR 985	06:11:49.0	+07:01:22	3	0.55 \pm 0.02	12.10 \pm 0.09	<8.60
SAI 63	FSR 987	06:13:44.5	+06:56:58	4	0.37 \pm 0.13	11.40 \pm 0.09	8.65 \pm 0.05
SAI 64	FSR 948	06:25:55.9	+15:51:39	4	0.08 \pm 0.13	11.84 \pm 0.17	9.00 \pm 0.05
SAI 65	FSR 979	06:31:16.2	+11:04:38	3	1.17 \pm 0.17	11.65 \pm 0.05	8.45 \pm 0.05
SAI 66	FSR 1063	06:34:37.9	-00:16:01	5	0.58 \pm 0.01	11.47 \pm 0.14	<8.60
SAI 67	Teutsch59	06:43:49.0	-00:52:60	6	0.57 \pm 0.14	12.34 \pm 0.04	<8.90
SAI 68	Patchick 90	06:44:42.7	-00:32:22	3	0.41 \pm 0.09	14.00 \pm 0.20	8.95 \pm 0.05
SAI 69		06:45:27.8	-11:47:40	3	0.35 \pm 0.07	14.27 \pm 0.10	9.10 \pm 0.05
SAI 70	FSR 1125	06:50:26.6	-05:26:08	4	0.39 \pm 0.01	13.99 \pm 0.09	<9.10
SAI 71	FSR 1085	06:53:11.2	-00:11:31	4	0.08 \pm 0.09	10.62 \pm 0.19	<8.60
SAI 72		06:55:48.4	+00:13:37	5	0.82 \pm 0.06	12.49 \pm 0.05	8.50 \pm 0.20
SAI 73	FSR 1171	07:00:13.1	-10:19:14	2	0.65 \pm 0.07	13.07 \pm 0.29	9.50 \pm 0.05
SAI 74	FSR 1150	07:04:36.6	-06:36:38	3	0.94 \pm 0.06	13.60 \pm 0.26	<8.30
SAI 75	Patchick 79	07:15:22.5	-07:25:20	4	0.23 \pm 0.03	12.24 \pm 0.24	<8.60
SAI 76	FSR 1253	07:26:17.4	-18:25:55	6	0.62 \pm 0.01	12.11 \pm 0.24	8.40 \pm 0.05
SAI 77	FSR 1275	07:28:06.2	-21:47:46	4	0.60 \pm 0.10	12.87 \pm 0.12	9.40 \pm 0.05
SAI 78	Teutsch 61	07:34:39.8	-19:47:23	3	0.55 \pm 0.02	11.42 \pm 0.10	6.95 \pm 0.05
SAI 79	FSR 1347	07:48:03.4	-33:42:35	6	1.09 \pm 0.15	11.95 \pm 0.07	<8.80
SAI 80	Teutsch 25	07:48:26.7	-27:54:51	5	0.57 \pm 0.12	11.48 \pm 0.16	<9.00

Table 1 (continued). Parameters of new clusters

Cluster	Other name	α_{J2000} $h\ m\ s$	δ_{J2000} $^\circ\ ' '$	d '	E(B-V) mag	$(m - M)_0$ mag	Age $\log(t)$
SAI 81		07:52:07.2	-28:07:21	7	0.40 \pm 0.02	12.21 \pm 0.19	< 9.20
SAI 82		07:52:14.4	-33:02:27	3	0.39 \pm 0.07	10.30 \pm 0.05	8.65 \pm 0.05
SAI 83		07:53:20.1	-32:33:30	3	1.00 \pm 0.15	12.96 \pm 0.34	8.85 \pm 0.05
SAI 84	Kronberger 85	07:58:21.6	-34:46:09	2	1.17 \pm 0.19	14.65 \pm 0.11	8.80 \pm 0.05
SAI 85	FSR 1378	08:01:11.5	-40:40:41	6	1.21 \pm 0.25	11.74 \pm 0.13	8.80 \pm 0.05
SAI 86		08:08:15.0	-36:36:33	6	0.69 \pm 0.09	12.41 \pm 0.16	8.60 \pm 0.05
SAI 87	FSR 1380	08:11:05.0	-39:59:51	4	1.28 \pm 0.30	11.80 \pm 0.19	< 8.65
SAI 88		08:12:57.6	-41:53:01	2	0.92 \pm 0.02	14.58 \pm 0.25	9.00 \pm 0.05
SAI 89	FSR 1387	08:24:25.3	-39:56:11	3	1.19 \pm 0.11	11.82 \pm 0.18	< 8.80
SAI 90		08:27:58.9	-41:46:10	7	1.02 \pm 0.21	12.19 \pm 0.11	9.05 \pm 0.05
SAI 91		08:37:03.4	-50:03:52	4	0.51 \pm 0.02	12.45 \pm 0.16	8.80 \pm 0.05
SAI 92	FSR 1436	08:39:34.5	-46:17:54	5	0.39 \pm 0.10	10.99 \pm 0.17	8.00 \pm 0.05
SAI 93	FSR 1415	08:40:21.9	-44:44:01	3	1.87 \pm 0.35	12.74 \pm 0.06	9.25 \pm 0.05
SAI 94		08:44:39.8	-46:17:46	5	0.48 \pm 0.05	12.96 \pm 0.29	9.10 \pm 0.10
SAI 95	FSR 1454	08:51:00.6	-48:27:37	5	0.57 \pm 0.03	13.96 \pm 0.05	9.15 \pm 0.05
SAI 96	FSR 1430	08:51:49.4	-44:15:47	4	2.50 \pm 0.33	12.27 \pm 0.33	8.85 \pm 0.05
SAI 98	FSR 1435	08:57:03.0	-43:45:40	6	1.06 \pm 0.06	10.27 \pm 0.30	9.75 \pm 0.10
SAI 99		08:58:04.4	-43:24:38	5	1.84 \pm 0.49	12.60 \pm 0.04	8.95 \pm 0.05
SAI 100	FSR 1450	08:58:12.2	-46:17:19	3	1.62 \pm 0.08	13.65 \pm 0.08	9.10 \pm 0.15
SAI 101		08:58:22.4	-43:07:35	5	1.56 \pm 0.04	11.09 \pm 0.05	< 9.00
SAI 102	FSR 1402	09:05:43.2	-37:52:05	4	0.08 \pm 0.04	12.03 \pm 0.29	9.60 \pm 0.05
SAI 103	FSR 1460	09:07:38.5	-47:50:01	7	1.31 \pm 0.20	11.30 \pm 0.70	9.30 \pm 0.70
SAI 104		09:09:54.8	-48:51:03	3	1.17 \pm 0.11	9.59 \pm 0.14	< 8.90
SAI 105		09:10:24.5	-49:54:46	4	1.91 \pm 0.31	12.35 \pm 0.13	9.05 \pm 0.05
SAI 106		09:17:59.4	-51:01:46	5	1.02 \pm 0.02	13.56 \pm 0.10	9.35 \pm 0.05
SAI 107	Teutsch 103	09:28:35.8	-46:35:60	3	0.62 \pm 0.06	12.23 \pm 0.38	< 8.75
SAI 108		09:38:52.9	-52:57:28	6	0.66 \pm 0.02	12.32 \pm 0.08	8.50 \pm 0.05
SAI 109		09:43:34.4	-50:47:33	5	0.23 \pm 0.04	14.43 \pm 0.50	9.20 \pm 0.20
SAI 110	FSR 1509	09:48:00.8	-55:04:01	2	1.17 \pm 0.13	11.59 \pm 0.05	8.75 \pm 0.05
SAI 111	FSR 1521	09:55:22.6	-56:36:15	8	0.90 \pm 0.17	13.00 \pm 0.30	9.45 \pm 0.10
SAI 112		10:21:24.9	-59:05:34	2	1.00 \pm 0.02	14.30 \pm 0.15	9.10 \pm 0.10
SAI 114	FSR 1555	10:48:55.7	-59:02:58	3	0.76 \pm 0.05	13.40 \pm 0.30	9.25 \pm 0.10
SAI 115	FSR 1586	11:22:44.9	-62:19:06	5	1.60 \pm 0.29	11.92 \pm 0.20	8.65 \pm 0.10
SAI 116		11:49:18.0	-62:13:47	5	0.98 \pm 0.08	11.72 \pm 0.17	8.60 \pm 0.05
SAI 117	FSR 1663	13:41:04.5	-60:12:27	4	1.01 \pm 0.16	11.66 \pm 0.25	8.90 \pm 0.05
SAI 118		13:43:03.8	-63:09:53	8	0.17 \pm 0.21	10.28 \pm 0.62	9.75 \pm 0.25
SAI 120		13:58:42.0	-61:40:08	2	1.99 \pm 0.30	12.03 \pm 0.21	8.75 \pm 0.10
SAI 121	FSR 1686	14:40:06.8	-60:23:13	5	1.48 \pm 0.23	13.02 \pm 0.16	8.95 \pm 0.05
SAI 122		15:00:03.9	-58:48:13	8	2.26 \pm 0.43	11.12 \pm 0.04	8.25 \pm 0.15
SAI 123		16:08:17.4	-50:32:06	7	1.35 \pm 0.18	11.35 \pm 0.18	9.20 \pm 0.05
SAI 124	FSR 1744	16:51:35.8	-42:25:47	3	2.58 \pm 0.34	12.48 \pm 0.26	8.85 \pm 0.20
SAI 127	FSR 124	19:06:52.8	+13:14:44	4	0.98 \pm 0.12	11.56 \pm 0.41	9.10 \pm 0.05
SAI 128	FSR 133	19:29:46.9	+15:33:51	6	2.26 \pm 0.45	11.59 \pm 0.12	8.35 \pm 0.05
SAI 129	FSR 160	19:44:44.3	+26:54:08	3	1.42 \pm 0.05	14.38 \pm 0.30	8.95 \pm 0.05
SAI 130	FSR 158	19:47:58.1	+26:01:55	8	1.17 \pm 0.04	12.78 \pm 0.11	< 8.30
SAI 131	FSR 154	19:48:00.8	+23:20:53	3	0.70 \pm 0.13	12.23 \pm 0.05	9.05 \pm 0.05
SAI 132		19:57:01.5	+31:36:31	8	0.94 \pm 0.09	12.28 \pm 0.06	8.75 \pm 0.05
SAI 133		20:01:58.7	+31:26:18	4	1.80 \pm 0.05	13.94 \pm 0.16	7.85 \pm 0.05
SAI 135		20:02:55.9	+24:33:17	5	1.34 \pm 0.29	12.89 \pm 0.06	9.10 \pm 0.05
SAI 136	Kronberger 36	20:04:35.7	+35:13:03	6	0.76 \pm 0.18	11.40 \pm 0.26	< 8.40
SAI 137		20:49:52.6	+41:15:18	6	0.89 \pm 0.08	10.12 \pm 0.24	< 8.70
SAI 138	FSR 275	20:56:43.0	+46:53:15	10	0.76 \pm 0.05	11.98 \pm 0.11	9.25 \pm 0.05
SAI 139	Teutsch 22	21:01:40.8	+44:06:43	2	0.86 \pm 0.13	12.16 \pm 0.33	8.55 \pm 0.05
SAI 140	FSR 282	21:02:20.1	+48:06:26	4	0.78 \pm 0.01	11.79 \pm 0.12	9.05 \pm 0.05
SAI 141		21:03:46.9	+46:58:50	3	0.94 \pm 0.04	13.47 \pm 0.16	8.60 \pm 0.05
SAI 142	Teutsch 156	21:03:46.7	+47:12:54	3	0.94 \pm 0.04	12.97 \pm 0.22	8.95 \pm 0.05
SAI 143		21:10:51.4	+50:18:31	3	1.72 \pm 0.24	14.07 \pm 0.17	9.25 \pm 0.05
SAI 144	Teutsch 74	21:45:43.6	+58:05:03	4	1.05 \pm 0.17	12.12 \pm 0.53	9.05 \pm 0.05
SAI 145	FSR 336	21:50:47.5	+55:16:31	8	0.55 \pm 0.09	11.67 \pm 0.37	8.90 \pm 0.05
SAI 146	FSR 342	22:07:38.6	+53:06:09	8	0.27 \pm 0.01	11.52 \pm 0.47	9.05 \pm 0.05
SAI 147	FSR 394	22:55:04.8	+58:42:53	5	0.70 \pm 0.04	13.73 \pm 0.21	9.40 \pm 0.05
SAI 148	FSR 430	23:15:29.5	+64:09:58	5	1.08 \pm 0.20	11.93 \pm 0.05	8.05 \pm 0.05
SAI 149		23:38:01.7	+60:32:57	7	1.29 \pm 0.30	11.87 \pm 0.07	< 8.20
SAI 150	FSR 441	23:41:58.8	+58:32:29	5	0.78 \pm 0.14	11.84 \pm 0.04	8.55 \pm 0.05
SAI 151	FSR 465	23:50:54.5	+66:10:49	5	0.78 \pm 0.04	13.60 \pm 0.10	9.20 \pm 0.05
SAI 153	FSR 460	23:59:07.0	+60:40:40	7	0.86 \pm 0.19	13.45 \pm 0.09	9.20 \pm 0.05

Table 3. Parameters of yet-unstudied clusters

Name	α_{J2000} <i>h m s</i>	δ_{J2000} $\circ \text{ } ' \text{ } ''$	d <i>'</i>	E(B-V) <i>mag</i>	$(m - M)_0$ <i>mag</i>	Distance pc	Age $\log(t)$
Koposov 7	05:40:44.1	+35:55:25	6	3.75 ± 0.37	13.39 ± 0.35	4760 ± 830	8.20 ± 0.05
ESO 368-11	07:44:22.2	-34:37:07	6	0.06 ± 0.10	10.86 ± 0.41	1490 ± 310	9.00 ± 0.05
ESO 311-21	08:01:41.6	-41:35:57	5	0.49 ± 0.02	11.84 ± 0.08	2330 ± 90	10.10 ± 0.05
Ru 48	08:02:42.5	-32:03:02	3	0.29 ± 0.04	12.41 ± 0.05	3030 ± 70	<8.60
Ru 54	08:11:21.7	-31:56:37	2	0.35 ± 0.04	12.71 ± 0.27	3480 ± 460	8.45 ± 0.05
Ru 60	08:24:23.0	-47:12:37	4	0.57 ± 0.06	12.84 ± 0.11	3700 ± 190	<8.65
ESO 312-03	08:24:26.1	-41:17:52	6	0.52 ± 0.10	11.68 ± 0.57	2170 ± 650	<8.90
ESO 312-04	08:26:51.2	-41:14:39	2	0.49 ± 0.01	11.91 ± 0.11	2410 ± 130	<8.75
Ru 63	08:32:41.4	-48:18:21	6	0.54 ± 0.04	12.13 ± 0.08	2670 ± 100	<8.50
Ru 68	08:44:34.5	-35:54:00	10	0.39 ± 0.05	11.49 ± 0.08	1990 ± 80	9.15 ± 0.05
ESO 211-03	08:51:34.3	-50:14:43	5	0.90 ± 0.07	12.88 ± 0.04	3770 ± 70	9.05 ± 0.10
TR 19	11:14:20.2	-57:33:04	14	0.08 ± 0.01	11.40 ± 0.05	1900 ± 50	9.65 ± 0.05
BH 131	12:26:13.7	-63:24:50	5	0.62 ± 0.04	13.98 ± 0.22	6250 ± 670	9.10 ± 0.10
Be 53	20:55:55.3	+51:02:54	10	1.31 ± 0.20	12.74 ± 0.13	3530 ± 220	9.15 ± 0.05